Some Ecological Trends in an Old Growth Red Pine Stand in Itasca State Park, Minnesota

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The extensive stands of old growth red pine (<u>Pinus resinosa</u>) are one of the primary attractions of Itasca State Park. The existence of these stands today is attributable to the frequent occurrence of forest fires in the park area during the eighteenth and nineteenth centuries. These fires served to reduce the competing vegetation and to create the mineral soil seed bed required for the establishment of red pine reproduction. With the recent fire protection policies the earlier successional patterns have been greatly altered.

In an effort to assess some of the changes which are now taking place in an old growth pine stand, Dr. E.V. Bakuzis of the University of Minnesota School of Forestry established in 1953 a system of permanent plots. These plots have been previously inventoried in 1953, 1959 and 1964. The data from these earlier studies has been considered with the 1968 inventory results and from it there appears to be some distinct ecological trends taking place in the stand.

<u>Study Area</u>

The stand being used in this long term study is located in Itasca State Park on the park drive west of Elk Lake. Its position is in the SW¼ and SE¼ of Section 16, T142N, R36W; it is an area managed as a wilderness study area. As Figure 1 indicates the stand (#13) is located in the edaphic field near the upper moisture and nutrient levels

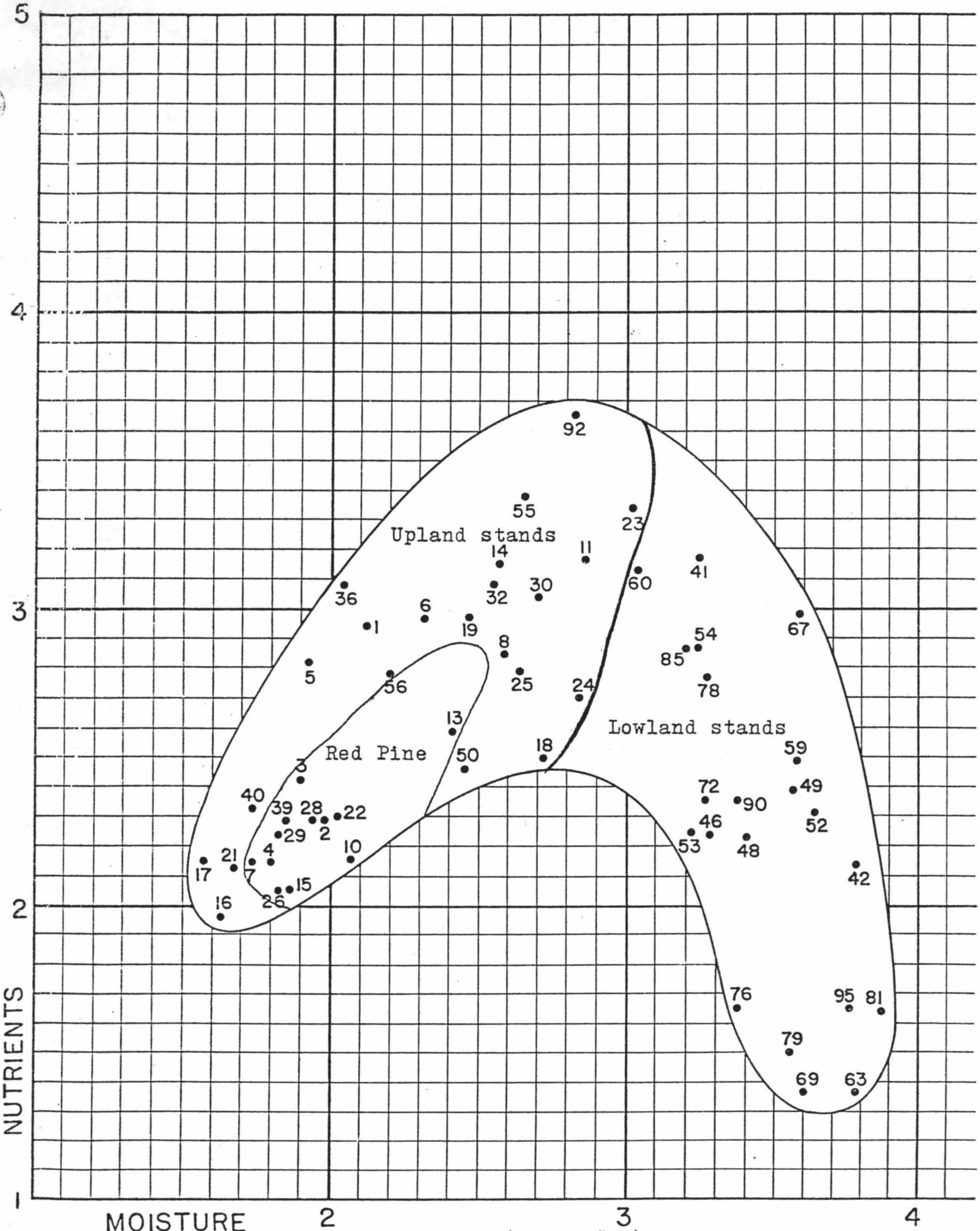


Figure 1: Position of the study area (point #13) in relation to the distribution of red pine in the edaphic field of the Central Pine Section of Minnesota (Bakuzis, E.V., unpublished data).

typical of the red pine distribution in the Central Pine Section of Minnesota.

Fire has been an important factor in the history of this stand. From a study of some of the old growth pine stands in the park, Spurr (1954) concluded that a severe fire occurred over most of the park around 1714. The oldest trees in the study area may well have been established as a result of this fire as increment counts indicate them to be around 250 years old. Spurr also cites a more recent fire in the region of the study area, this one occurred about 1820. Trees of this age class are present in the stand as well as other age classes suggesting more localized fires of less severity than those mentioned.

More recent disturbance in the stand occurred in the 1930's at which time the Civilian Conservation Corps thinned some of the balsam fir (Abies balsamea) understory. The effect of this thinning is still evident and is partly the basis upon which five subdivisions can be delineated in the stand. Figure 2 shows a diagram of the transect and indicates the position of the plots and subdivisions. Subdivisions 2 and 3 were the most affected by the thinning.

Blowdown involving primarily the balsam fir occurred in 1952 and to a lesser extent in 1968. This occurred mainly in subdivisions 4 and 5.

Methods

Forty plot centers are permanently located in the stand. At each point four concentric circular plots (10, 40, 70 and 100 square meters) were laid out. In the 10

TRANSECT OF PERMANENT STUDY AREA
IN RED PINE-BALSAM FIR FOREST

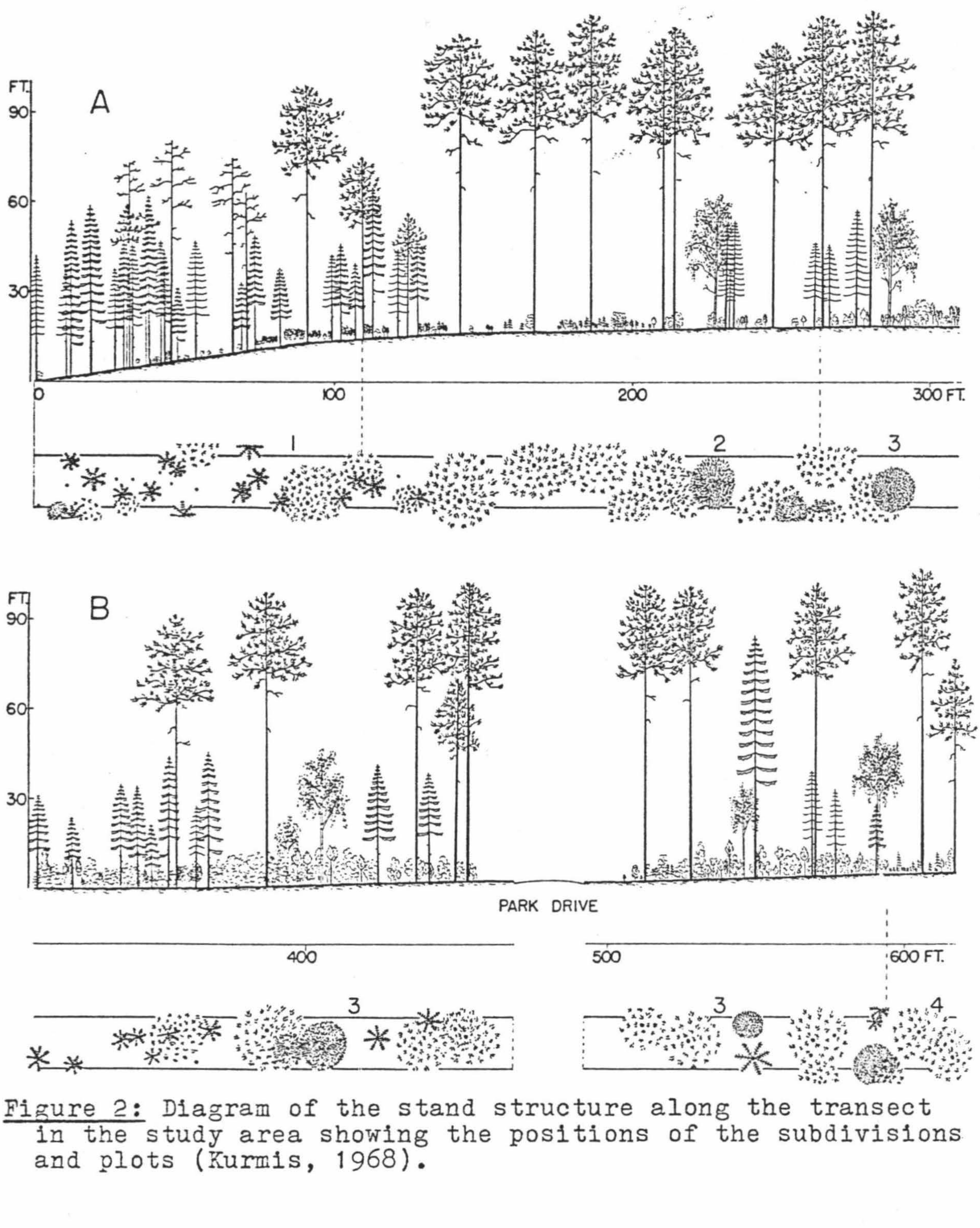


Figure 2: Diagram of the stand structure along the transect in the study area showing the positions of the subdivisions and plots (Kurmis, 1968).

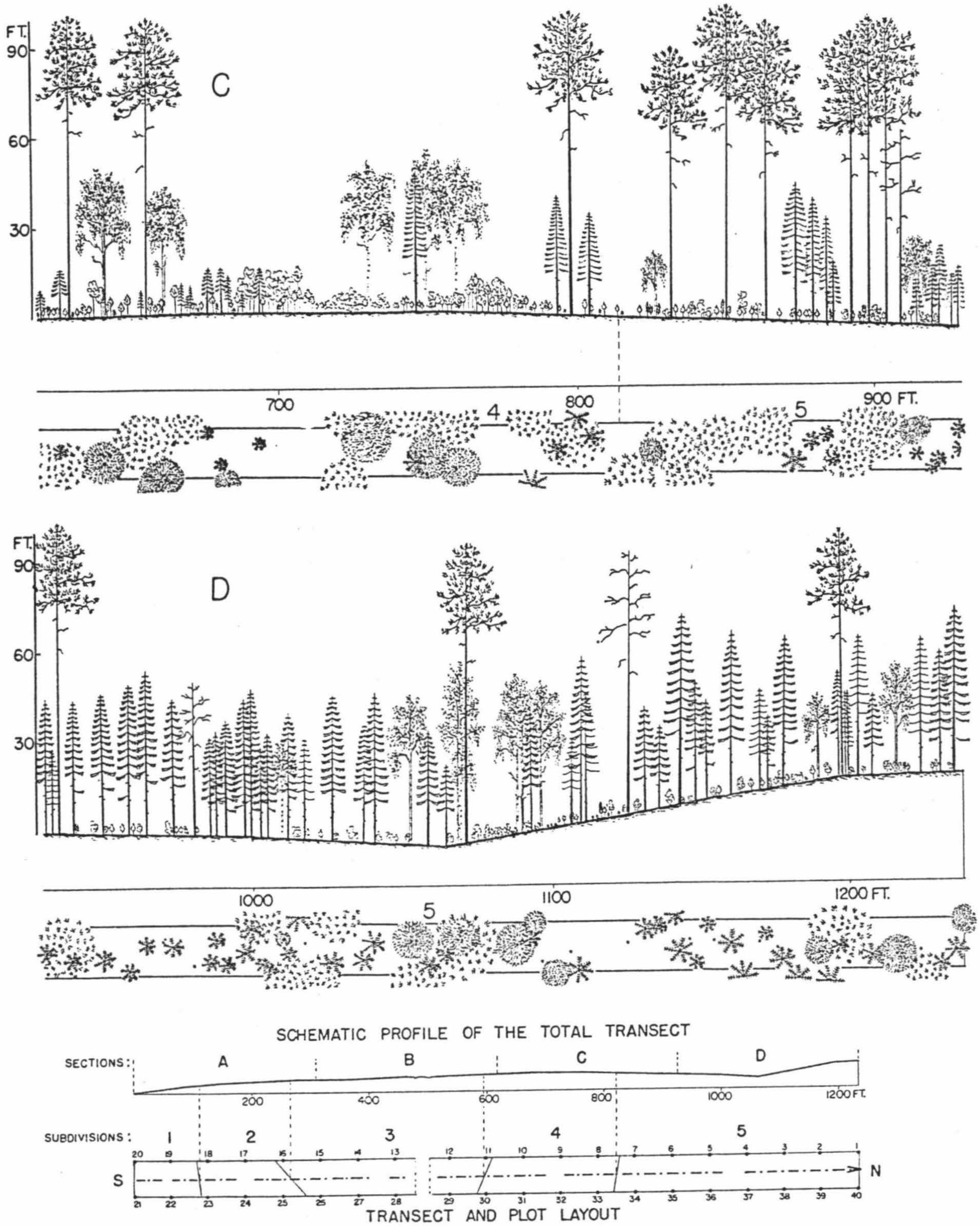


Figure 2: (continued)

square meter plot the presence of all understory species and reproduction (less than one inch dbh) was recorded and the dominance estimated according to the Braun-Blanquet cover-abundance scale. All of the reproduction and shrub species were counted, their height measured and age estimated.

Trees and saplings were recorded for each concentric plot. The diameter of each individual was measured. Height, diameter and age measurements were taken on thirty trees representing the different dominant species and the different subdivisions.

Light measurements were made in foot candles with a hand held meter. Readings were taken at points ½, 1, 3 and 4.5 feet above the ground at the plot center and at eight points consistently located about the center. All readings were taken in a three hour period at midday of a clear day. Readings were also taken in the open both before and after the measurement period.

Results and Discussion

1. Floristic trends

Table 1 lists the species present in the plots at the time of each of the four inventories.

Figure 3 shows the trends in the number of species present in each of the subdivisions and for the area as a whole. This indicates that there has been a taxonomic diversification in the stand between 1953 and 1964. In the past four years this appears to have stabilized and there has even been a slight decline in the entire stand. Inspite of this decline the diversity in the subdivisions tended to increase indicating a trend toward

TABLE 1: Species Present in Permanent Study Area

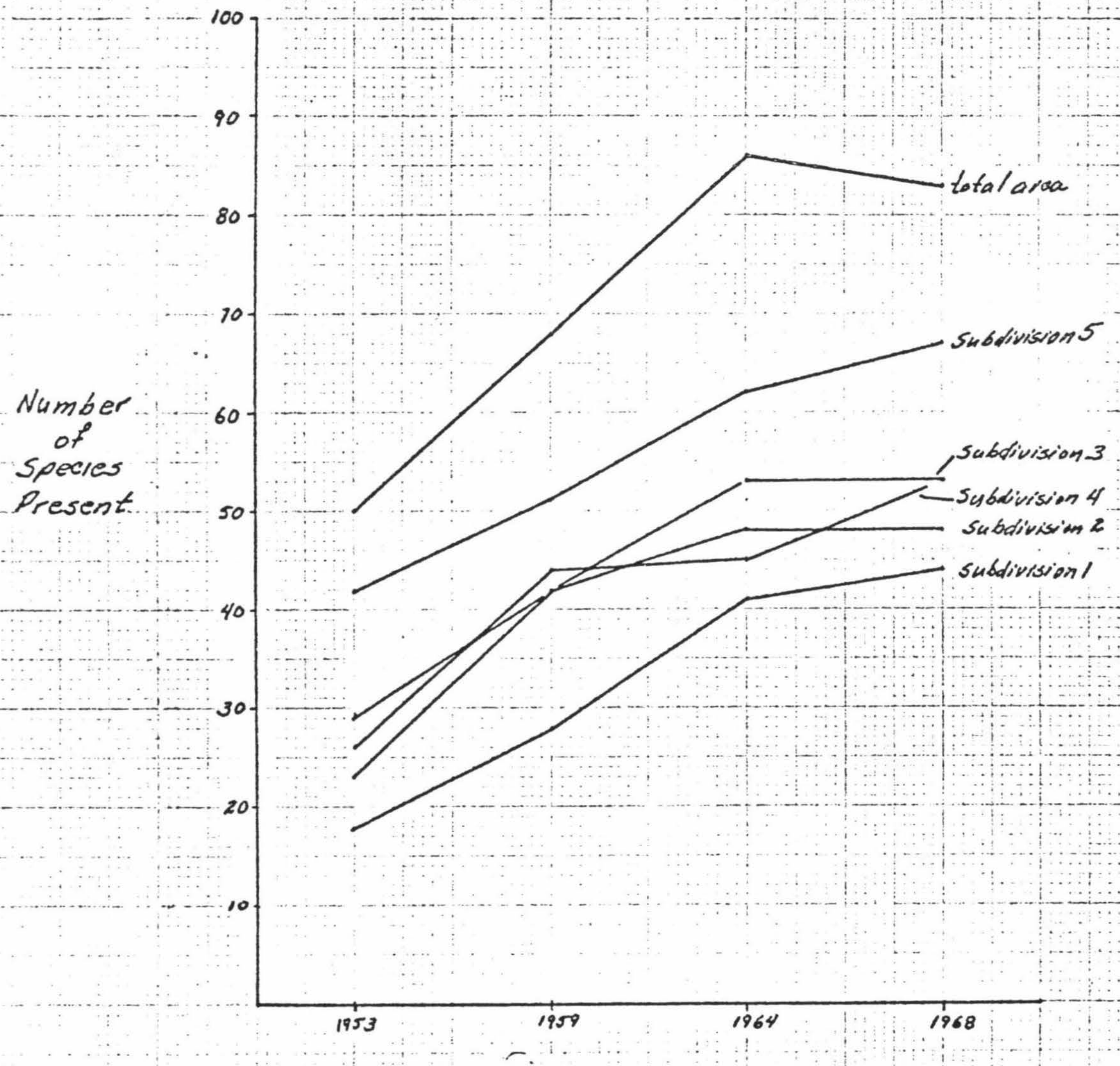
	Years present			
	1953	1959	1964	1968
Trees				
Abies balsamea	x	x	x	x
Acer rubrum	x	x	x	x
Acer saccharum				x
Betula papyrifera	x	x	x	x
Fraxinus nigra	x	x	x	x
Picea glauca	x	x	x	x
Pinus resinosa	x	x	x	x
Pinus strobus	x	x	x	x
Quercus macrocarpa	x			x
Quercus rubra	x	x	x	x
Ulmus americana			x	x
Shrubs				
Acer spicatum	x	x	x	x
Amelanchier spp.	x	x	x	x
Cornus rugosa				x
Corylus cornuta	x	x	x	x
Diervilla lonicera	x	x	x	x
Lonicera canadensis	x	x	x	x
Lonicera hirsuta			x	x
Prunus pennsylvanica	x	x	x	x
Prunus virginiana	x	x	x	x
Ribes americanum		x	x	x
Rosa acicularis			x	x
Salix humilis			x	x
Sambucus canadensis		x	x	x
Sambucus pubens			x	x
Sorbus americana			x	x
Symphoricarpos albus	x	x	x	x
Viburnum rafinesquianum	x		x	x
Halfshrubs and Vines				
Chimaphila umbellata	x	x	x	x
Gaultheria procumbens	x		x	
Parthenocissus quinq.			x	x
Rhus radicans		x	x	x
Rubus alleghaniensis		x	x	x
Rubus id. v. strigosus	x	x	x	x
Rubus pubescens	x	x	x	x
Vaccinium angustifolium			x	x
Vaccinium myrtilloides	x	x	x	x
Ferns and Allies				
Dryopteris spinulosa	x	x	x	x
Lycopodium annotinum			x	
Lycopodium complanatum	x		x	x
Lycopodium obscurum		x	x	x
Pteridium aquilinum	x	x	x	x
Monotropa uniflora				x

TABLE 1: (continued)

	1953	1959	1964	1968
<u>Mosses and Lichens</u>				
Dicranum rugosum	x	x	x	x
Hypnum-Hylocomium spp.	x	x	x	x
Mnium spp.	x	x	x	x
Pleurozium schreberi	x	x	x	
Polytrichum juniperinum	x	x	x	x
<u>Forbs</u>				
Amphicarpa bracteata			x	x
Anemone cylindrica			x	
Anemone quinquefolia		x	x	x
Antennaria canadensis		x	x	
Apocynum androsaemifolium	x	x	x	x
Aquilegia canadensis		x	x	x
Aralia nudicaulis	x	x	x	x
Aralia racemosa		x	x	
Arisaema atrorubens		x		x
Aster laevis			x	
Aster macrophyllus	x	x	x	x
Circaea alpina	x	x	x	x
Cirsium arvense		x		
Clintonia borealis	x	x	x	x
Cornus canadensis	x	x	x	x
Fragaria vesca				x
Fragaria virginiana		x	x	x
Galium boreale	x	x	x	x
Galium triflorum	x	x	x	x
Goodyera repens	x	x	x	x
Habenaria orbiculata			x	x
Hepatica americana	x	x	x	x
Impatiens pallida			x	
Lathyrus ochroleucus		x	x	x
Lathyrus venosus		x	x	x
Linnaea borealis	x	x	x	x
Maianthemum canadense	x	x	x	x
Mitella nuda			x	
Osmorhiza claytoni		x	x	x
Petasites palmatus		x		
Polygonatum pubescens			x	x
Pyrola virens	x	x	x	x
Sanicula marikandica		x	x	
Streptopus roseus	x	x	x	x
Taraxacum officinale			x	x
Thalictrum dioicum	x	x	x	x
Trientalis borealis		x	x	x
Uvularia sessilifolia			x	
Vicia americana	x	x	x	x
Viola conspersa	x	x	x	x
Viola incognita	x	x	x	x
Viola pallens			x	x
Viola rugulosa		x	x	x
<u>Grasses and Sedges</u>				
Agrostis alba		x		x
Calamagrostis inexpansa	x	x	x	x
Cinna latifolia			x	x
Oryzopsis asperifolia	x	x	x	x
Oryzopsis pungens				x
Schizachne purpurascens				x

FIGURE 3:

TAXONOMIC DIVERSITY TRENDS



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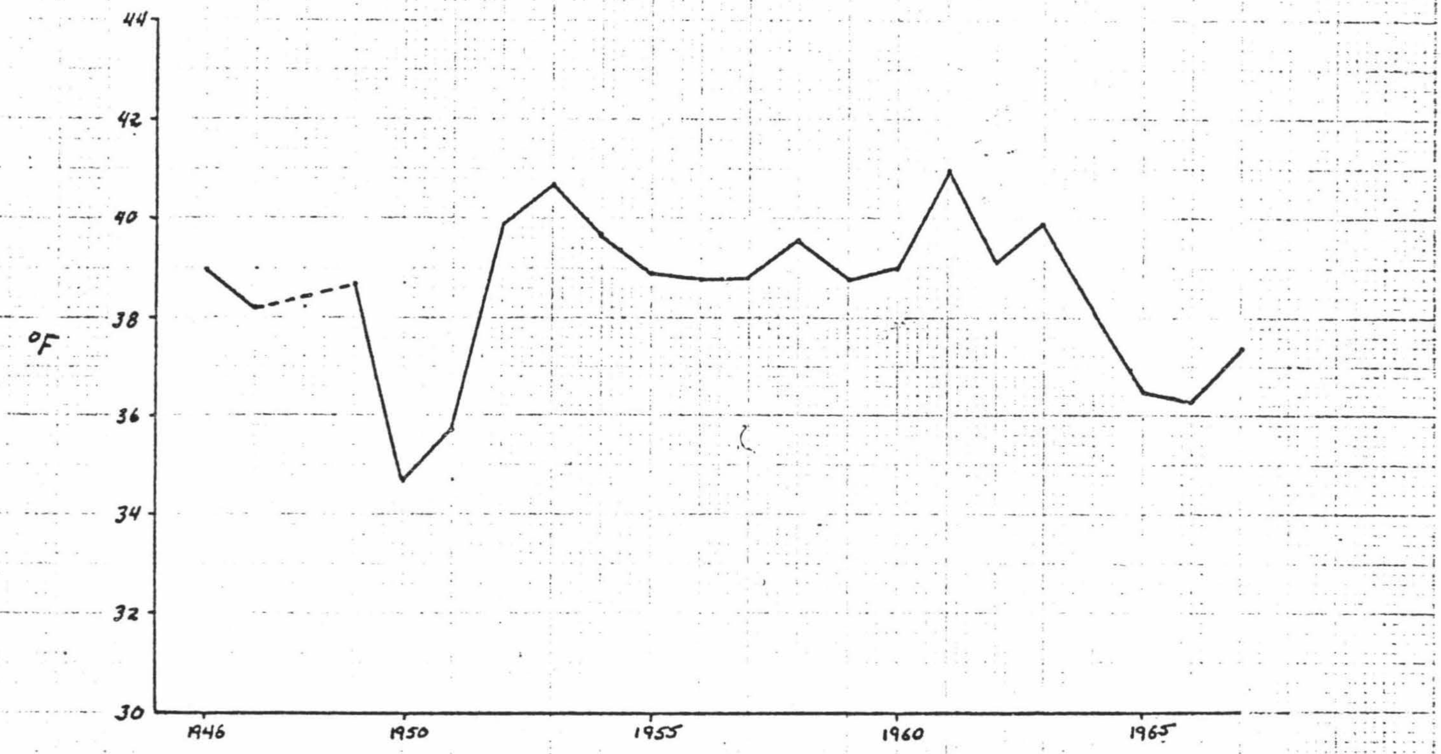
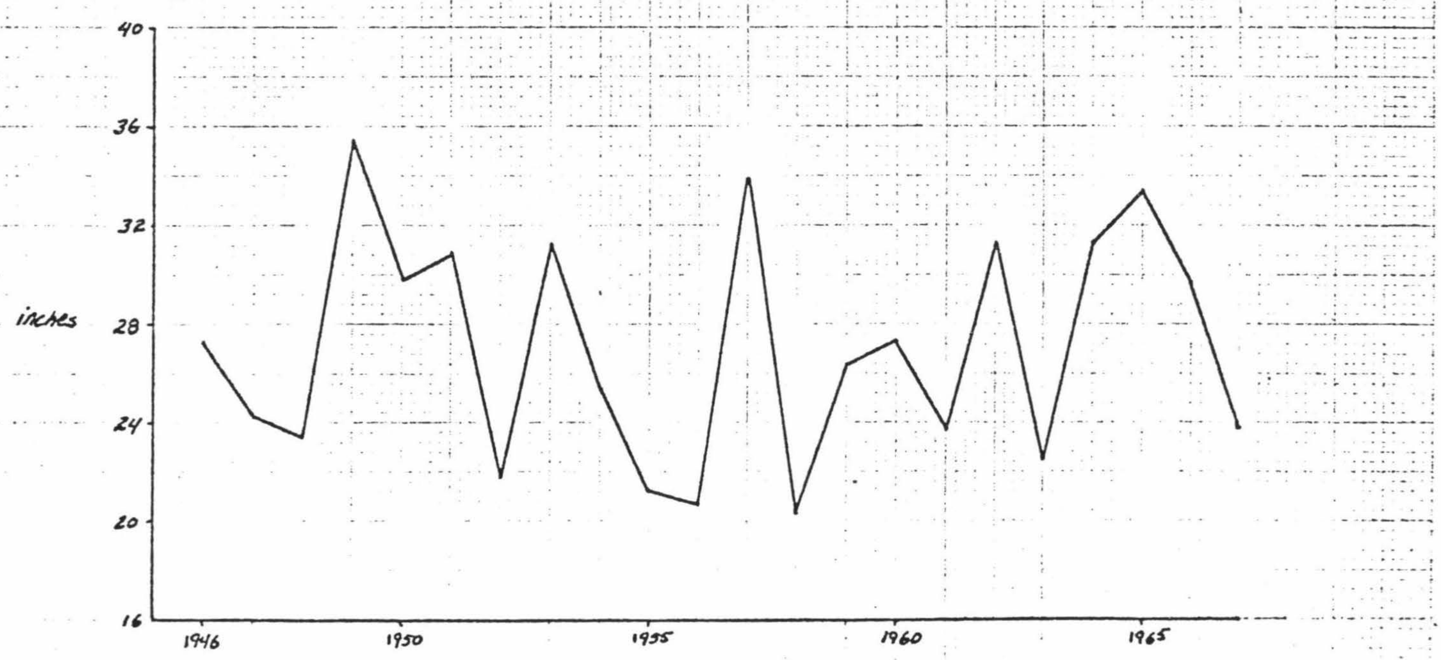


Graph of the average annual temperature at the Itasca State Park weather station, 1946-1967.



Graph of the total annual precipitation at the Itasca State Park weather station, 1946-1967.

a more floristically homogeneous condition for the stand as a whole.

2. Overstory trends

During the period of the study there have been only slight changes in the stand overstory (trees greater than one inch dbh). Figure 4 expresses these changes as a function of basal area for the major species. Balsam fir shows a slight decline and then increase in basal area since 1953. White spruce (Picea glauca), white pine (Pinus strobus) and paper birch (Betula papyrifera) all show gradual increases over the fifteen year period though they only constitute a relatively small amount of the total area.

Red pine shows the greatest change, declining between 1953 and 1964 and then increasing sharply since 1964. Some of this increase may be attributable to the use of a diameter tape in 1968 rather than tree calipers as in previous years. If this were solely the cause it would be expected that the other species would also exhibit an abrupt increase, but they do not. It would thus be due primarily to an increase in growth rate. The observed basal area increase is consistent with the growth potential of red pine on a site index of 55 and under density conditions comparable to those in the study area (Buckman, 1962).

Inspite of this increase red pine appears to be beginning to lose its dominance in the stand. This is shown by Figure 5, a graph of basal area by species as a percentage of the total area in the stand. Athough this is slight it would be expected that this declining trend will continue and steepen in the future as the red pine

Figure 4: Basal Area for Major Species

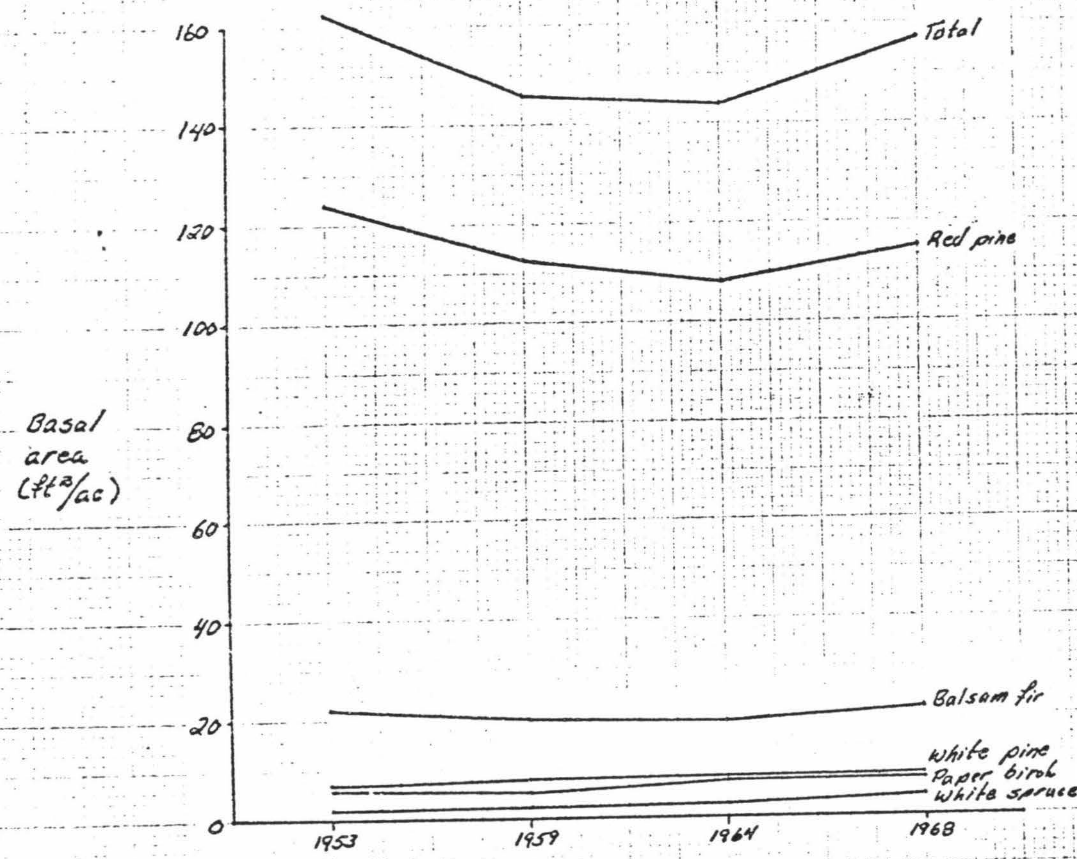
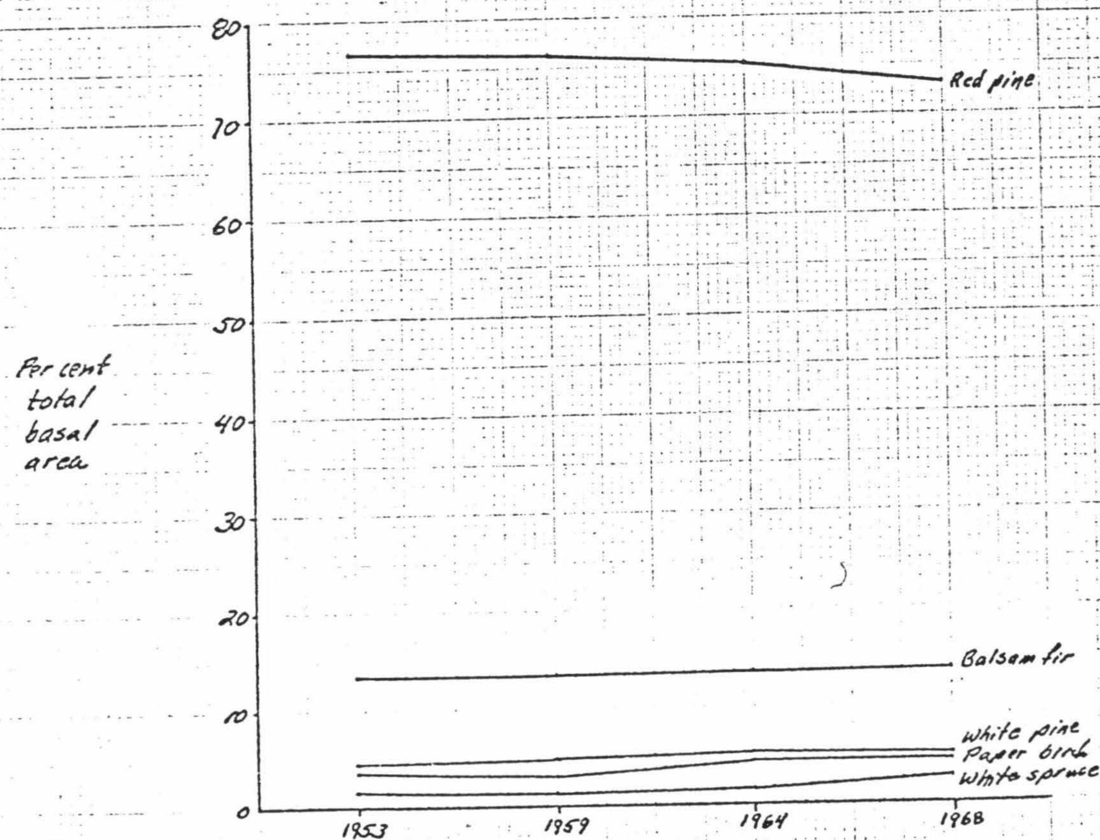


Figure 5: Percent Total Basal Area for Major Species



overstory begins to break up and the hardwoods and other conifer species show rapid growth in the sapling and small tree classes.

3. Reproduction trends

The reproduction density in stems per acre for each of the inventory years appears in Table 2. These figures are computed as an average for all five subdivisions combined. The apparent inconsistencies in successive age classes and inventories are the result of the difficulties inherent in age estimation, especially in cases where the individual plant has been suppressed or when the plant is a very rapidly growing one such as the hazel sprouts.

To partly overcome this Figure 6 graphs the trends in reproduction density on the basis of a broad age class, three to ten years of age. The one and two year old plants have not been included as the great fluctuations in annual seed crop production and the high seedling mortality in the first two years would obscure trends in the effective reproduction.

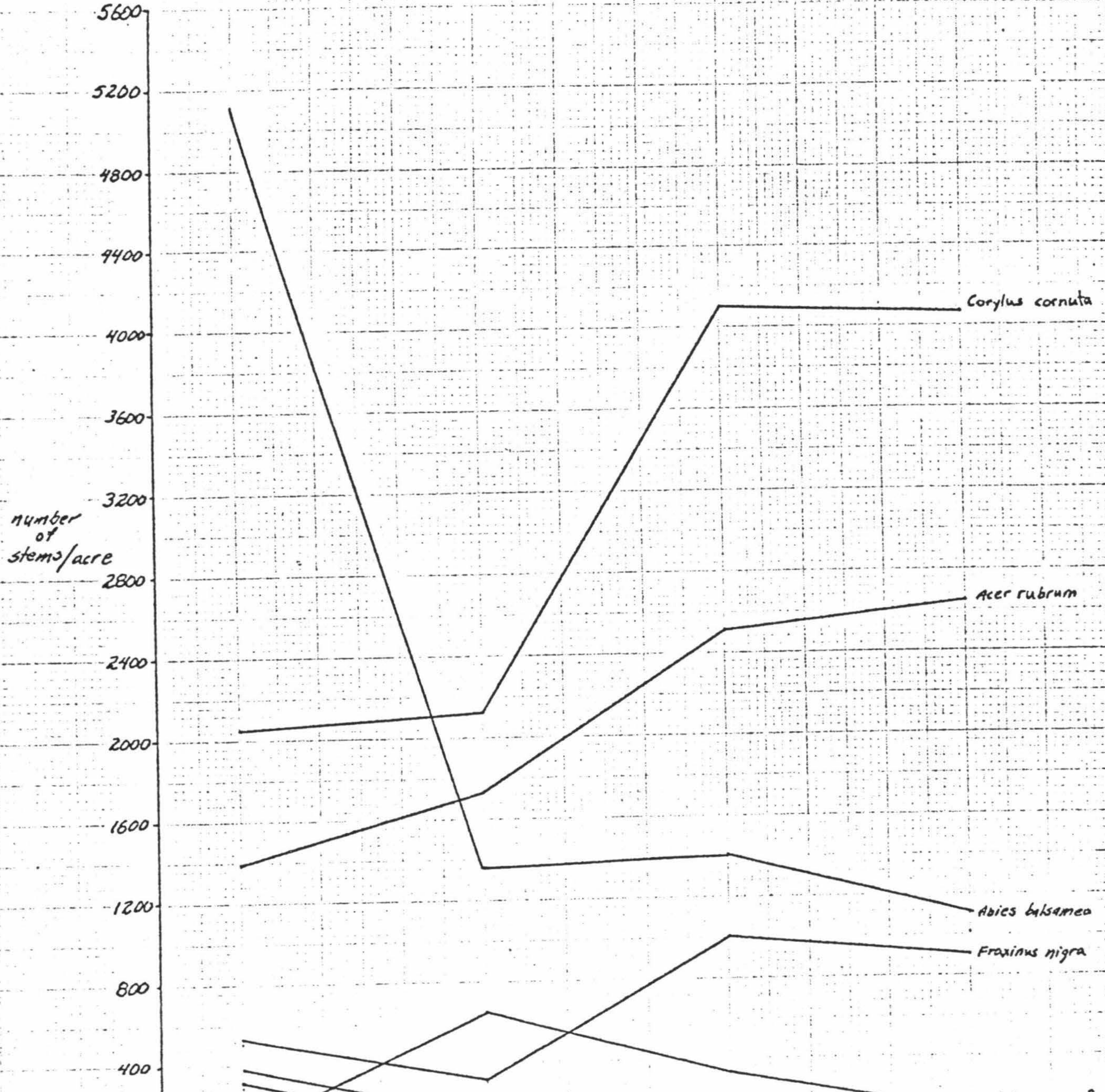
In the graph balsam fir shows a decline in density during the fifteen year period. This decline is due to growth into the next age class and evidently the weather conditions prevailing during the period have been unfavorable for balsam fir seedling survival. Consequently there has not been a large repopulation of the lower age classes. With the fairly high first year seedling count in 1968 it would be expected that the curve will rise in the near future if the weather conditions are favorable.

Both of the pine species show a gradual decline in abundance during the study period. This can most certainly

TABLE 2: Total Shrubs and Reproduction (# stems per acre)

Age class (yrs)	1953 1-2	1953 3-5	1953 6-10	1959 1-2	1959 3-5	1959 6-10	1964 1-2	1964 3-5	1964 6-10	1968 1-2	1968 3-5	1968 6-10
Species												
Abies balsamea	3410	3370	1550	100	370	990	830	900	510	17210	760	360
Acer rubrum	930	1150	240	470	980	750	2050	1380	1130	710	1330	1320
Acer saccharum	0	0	0	0	0	0	0	0	0	0	10	0
Acer spicatum	0	10	20	10	10	20	0	50	50	0	0	0
Betula papyrifera	380	60	20	920	620	30	470	230	100	20	100	20
Corylus cornuta	310	1030	1020	340	760	1370	760	1810	2290	1450	2730	1340
Fraxinus nigra	550	370	160	1500	80	240	380	560	450	80	480	420
Picea glauca	0	20	10	0	0	0	80	10	10	0	0	0
Pinus resinosa	~~30~~ 100	~~220~~ 200	~~100~~ 60	0	40	20	~~10~~ 20	~~40~~ —	~~20~~ —	10	0	0
Pinus strobus	70	270	110	0	60	70	20	90	40	300	30	10
Prunus spp.	0	20	0	70	30	90	0	50	130	50	70	80

FIGURE 6: SHRUBS AND REPRODUCTION
3-10 year age class



be attributed to the absence of favorable seed bed conditions consequent to the reduction of forest disturbances.

Paper birch (Betula papyrifera) also shows a decline though after peaking in 1939. The other major species, hazel (Corylus cornuta), red maple (Acer rubrum) and black ash (Fraxinus nigra), show an increasing density over the period. In the past four years, however, the curves suggest a possible stabilization although a single year's observation is inadequate to conclude this. It would seem quite possible that the maple and possibly the ash will show a further increase while the hazel will decline as the overstory becomes more dense due to balsam fir and hardwood growth in the tree and sapling classes.

This is also suggested by the graph of hazel [illegible] (Figure 7) according to its density in each subdivision. Like red maple it shows a density increase in a south to north direction. This density gradient follows an increasing heat and light gradient as shown by the synecological coordinates of each subdivision. The moisture regime shows a reverse gradient and black ash appears to follow this most closely.

Red pine shows a progressive restriction over time to subdivision five where it has maintained a fairly constant density (all age classes) for the past nine years. The 1968 density distribution for white pine shows a sharp deviation in subdivisions 1 and 4 from that in previous years.

Balsam fir also shows a low density in subdivision 4

REPRODUCTION AND OTHER STAND CHARACTERISTICS BY YEARS AND DIFFERENT SUBDIVISIONS OF THE TRANSECT

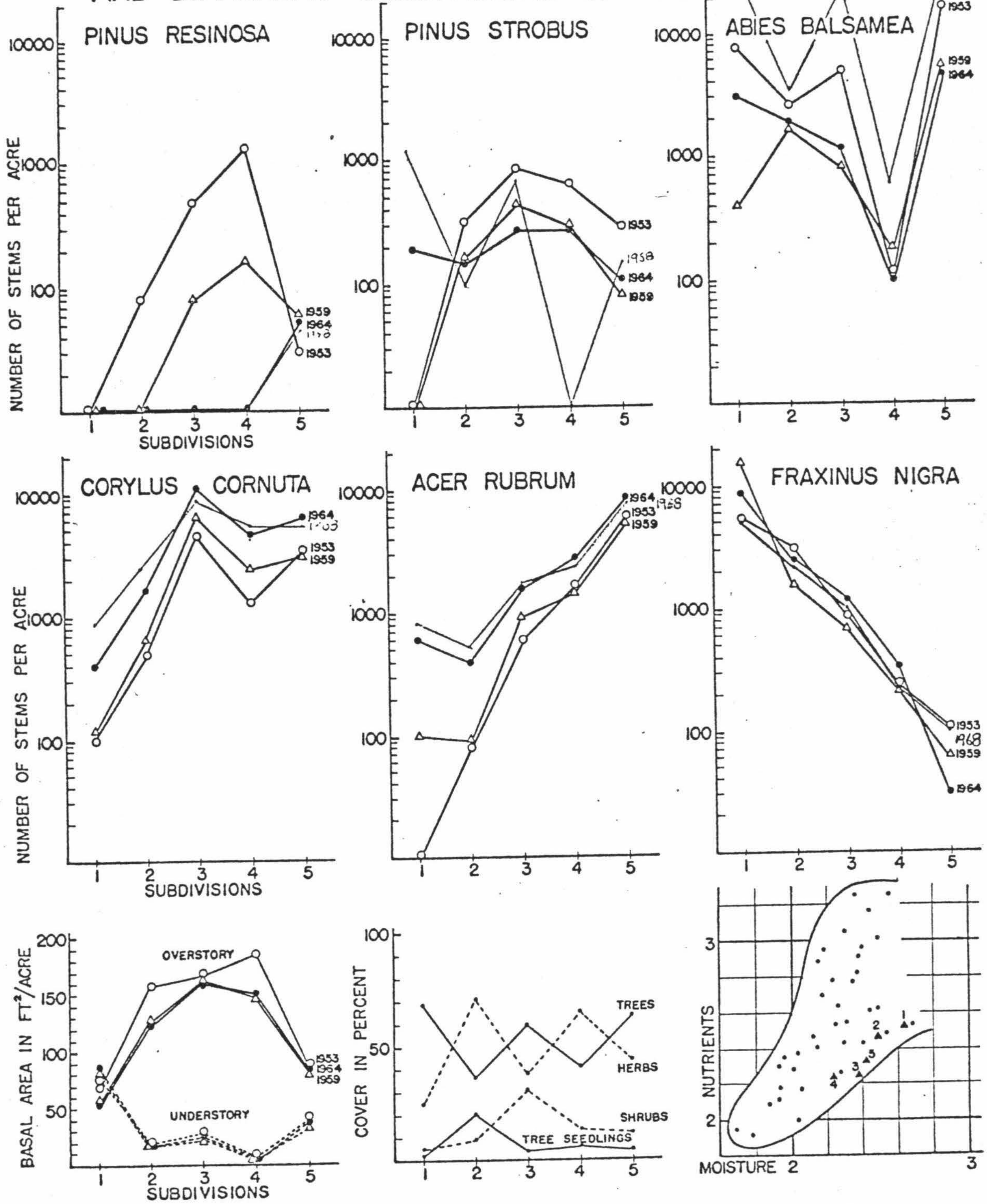


Figure 7: Graphs of the reproduction density by species, years and subdivisions. Basic graph and all data except 1968 from Kurmis (1968).

although this has been consistently the case. The synecological coordinates for this subdivision indicates that it has the most rigorous light and moisture regimes of the five subdivisions.

4. Synecological coordinate trends

Synecological coordinates offer a means of summarizing and generalizing the environmental conditions of an area as they are expressed through the species present in the area. The use of coordinates is a method of ecological groupings which, according to Ellenberg (1956), are groups of species that are similar in their relationships to environmental factors. The synecological coordinates as developed by Bakuzis (1959, 1961, 1967) for Minnesota forest species positions the individual species in a four dimensional field. The coordinate axes for the field are moisture, nutrient, heat and light each with a relative scale of 1 (lowest) to 5 (highest). Thus the requirements and tolerances of a species can be generalized with four coordinates.

The environmental conditions in a stand or other area can then be generalized by an average of the coordinates of of the species present in it. There are several ways of determining the average stand coordinates. Each of the ways appears to show trends and differences which are of different types and causes. Table 3 summarizes the coordinates for the entire study area as computed by four different methods.

Table 3a is of averages based on each of the plots in the study area. Here plot coordinates were determined and these were then averaged to arrive at the stand

TABLE 3: Average Synecological Coordinates for the Stand

3a. Average by plots

Year	M	N	H.	L
1953	2.49	2.10	1.87	2.79
1959	2.34	2.19	2.03	2.96
1964	2.40	2.20	2.08	2.89
1968	2.46	2.21	2.01	2.87

3b. Average of Five Subdivisions

Year	M	N	H	L
1953	2.39	2.15	1.96	2.80
1959	2.30	2.33	2.13	3.00
1964	2.38	2.33	2.15	2.97
1968	2.47	2.38	2.10	2.90

3c. Average for Total Area (Pooled species list)

Year	M	N	H	L
1953	2.28	2.24	2.12	2.88
1959	2.38	2.43	2.19	2.88
1964	2.41	2.48	2.28	2.90
1968	2.43	2.55	2.31	2.88

3d. Average on Dominance Basis by plots

Year	M	N	H	L
1968	2.44	2.03	1.92	2.74

Peak values for each coordinate are underscored.

coordinates. The stand coordinates are thus weighted by the frequency of the species in the area. As species frequency, especially for annuals, will be influenced by year to year weather conditions the coordinate trends indicated by this method of averaging would appear to greatly reflect short term weather and climatic changes.

Values computed by weighting according to abundance and cover (Table 3d) would be even more responsive to these fluctuations. In this table the coordinates for each species were weighted by the species' dominance in the plot as estimated according to the Braun-Blanquet cover-abundance classification. The average stand values computed this way are generally lower than those computed by the other methods.

The stand coordinates in Table 3b are averages of the subdivision coordinates. Here each species in a particular subdivision is given the same weight. The final stand value will thus be slightly weighted in favor of the most widespread species.

Table 3c is computed from the list of species for the entire area (Table 1). Here all species are given the same weight regardless of their abundance or importance in the stand. Any trends in the stand conditions indicated by these average coordinates would seem to be primarily the result of rather large changes in the stand, perhaps large scale successional or climatic trends. Working this way on the basis of a pooled list, provides a certain degree of stability to the values as it blots out the short term fluctuations in species composition and abundance.

Conclusion

From the fifteen years so far completed in this study some trends are evident in the stand development. The red pine is beginning to show a decline in importance in the stand and with the lack of any successful reproduction this should certainly continue. The breakup of the overstory is further suggested by the trend of light penetration to the forest floor. It increased by 10 percent (percent of external light) from 1953 to 1964 but now appears to be decreasing due to the increase of size and abundance of saplings.

Shrub density has also increased but there is a tentative suggestion that it is stabilizing. Whether this is a true stabilization or just a short term plateau can not be known until future inventories.

The same is true for the apparent trend in taxonomic diversity. This also appears to be stabilizing with the concurrent mesification trend indicated for the stand as a whole by the synecological coordinates determined on a completely unweighted basis.

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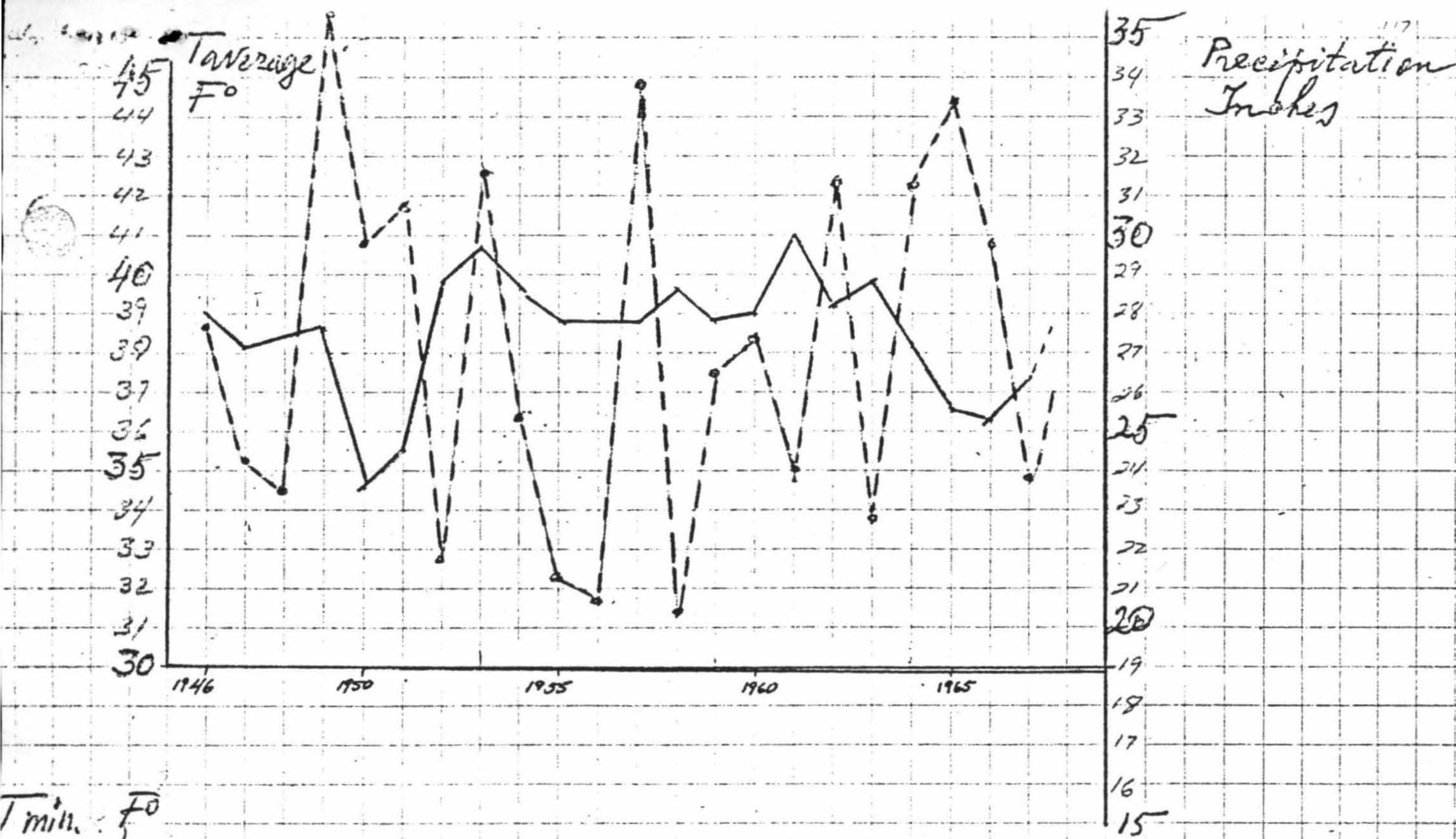
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Precipitation Inches
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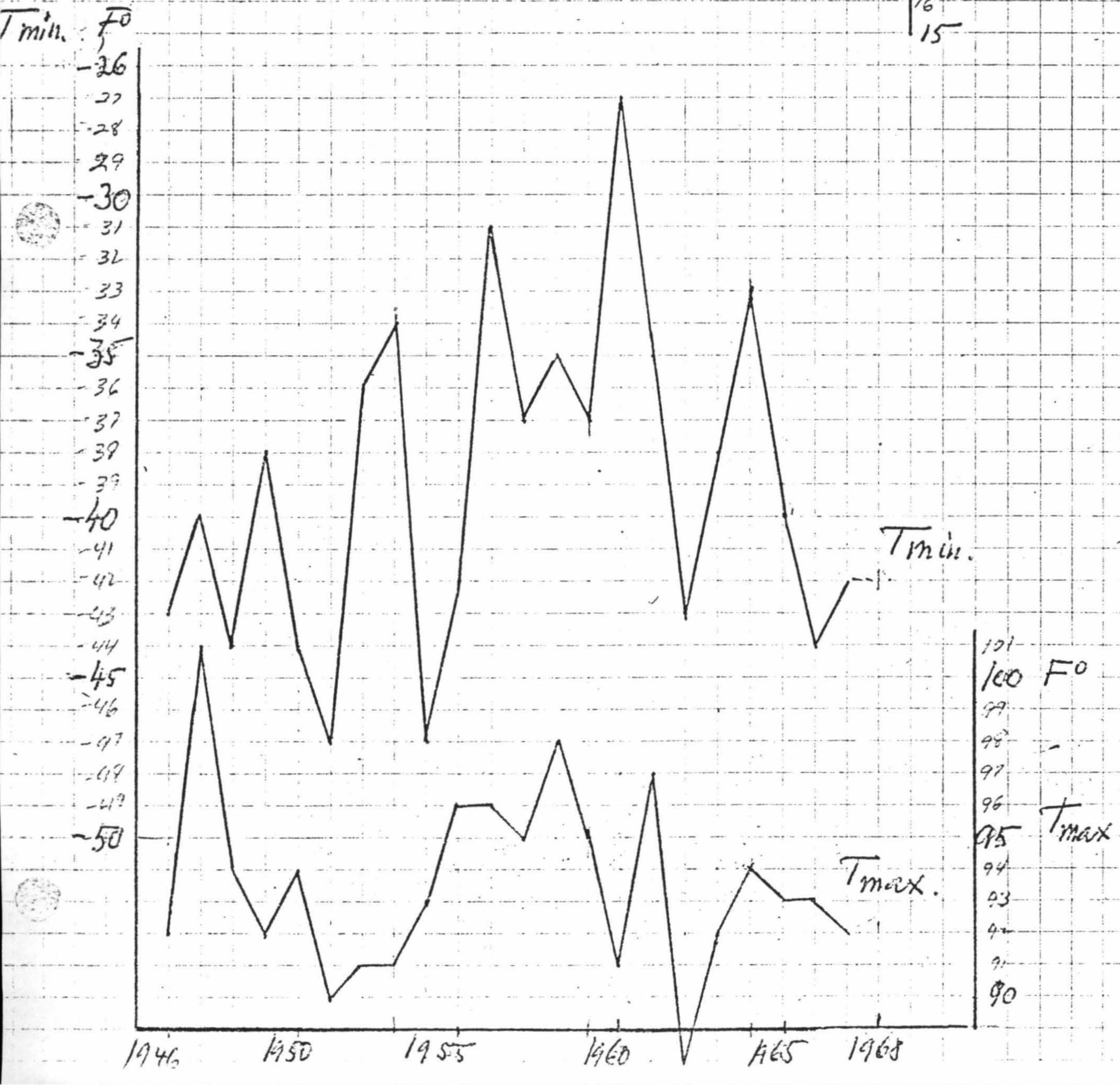
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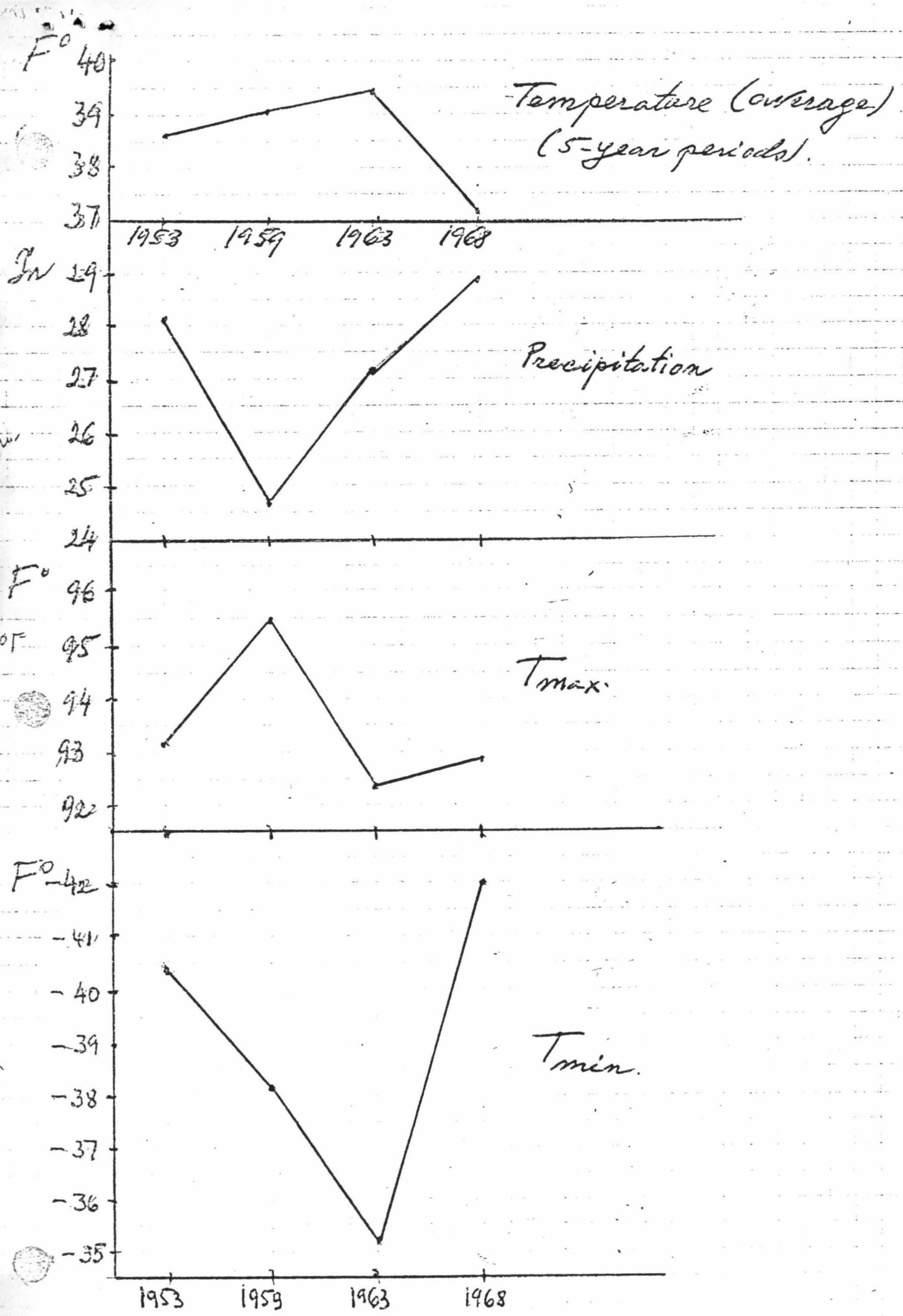
F°
40
39
38
37
1953
1959
1963
1968
Temperature (average)
(5-year periods).
In
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28
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26
25
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Precipitation
F°
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95
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Tmax.
F°
-42
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